WE CLAIM:

1. An apparatus comprising:

a carbonaceous material reactor vessel having a carbonaceous material inlet, an hydrogen-rich gas outlet, a retentate gas outlet, a reaction zone containing a carbonaceous material, and a product gas zone containing reaction product gas; and

at least one permeable hydrogen-selective membrane disposed within said carbonaceous material reactor vessel and having a first side in contact with said reaction product gas and an opposite second side in contact with an hydrogen-rich gas.

2. An apparatus in accordance with Claim 1, wherein said carbonaceous material reactor vessel is a gasification reactor vessel.

3. An apparatus in accordance with Claim 2, wherein said at least one permeable hydrogen-selective membrane is at least one of proton conductive and electron conductive.

4. An apparatus in accordance with Claim 3, wherein said at least one permeable hydrogen-selective membrane is proton conductive and electron conductive.

5. An apparatus in accordance with Claim 2, wherein said permeable hydrogen-selective membrane is operable at temperatures up to at least about 2000°C.

6. An apparatus in accordance with Claim 2, wherein said permeable hydrogen-selective membrane comprises a membrane material selected from the group consisting of Pd, Pd-Ag alloy, Pd-Cu alloy, perovskite-type ceramic materials, composites of Pd and ceramic materials, and combinations thereof.

7. An apparatus in accordance with Claim 2, wherein said permeable hydrogen-selective membrane comprises a ceramic material of perovskite oxide having a formula

$$A_{1-x}A'_xB_{1-y}B'_yO_{3-z}$$

where A is selected from the group consisting of Ba, Sr, Ca and Mg, A' is selected from the group consisting of La, Pr, Nd, Gd, and Yb, B and B' are selected from the group consisting of Ce, Nd, Sm, Eu, Gd, Tm, Yb and Y, O is oxygen, x and y are numbers in a range of 0 to 1, and z is a number sufficient to neutralize a charge in said perovskite oxide.

8. An apparatus in accordance with Claim 2, wherein said at least one permeable hydrogen-selective membrane is disposed within a membrane module disposed within said gasification reactor vessel.

9. An apparatus in accordance with Claim 8, wherein said at least one permeable hydrogen-selective membrane is in one of a sheet form and a tubular form.

10. An apparatus in accordance with Claim 6, wherein said perovskite-type ceramic material comprises an electron conductive metal.

11. An apparatus in accordance with Claim 10, wherein said electron conductive metal is selected from the group consisting of Ni, Pd, Pt and combinations thereof.

12. An apparatus in accordance with Claim 8, wherein a solid particle, impermeable-gas permeable protective sheath is disposed around said membrane module.

13. An apparatus in accordance with Claim 2, wherein said gasification reactor vessel is a fluidized bed gasification reactor.

14. An apparatus in accordance with Claim 1, wherein said carbonaceous material reactor vessel is a gas phase reactor vessel.

15. An apparatus in accordance with Claim 14, wherein said at least one permeable hydrogen-selective membrane is at least one of proton conductive and electron conductive.

16. An apparatus in accordance with Claim 15, wherein said at least one permeable hydrogen-selective membrane is proton conductive and electron conductive.

17. An apparatus in accordance with Claim 14, wherein said permeable hydrogen-selective membrane is operable at temperatures up to at least about 2000°C.

18. An apparatus in accordance with Claim 14, wherein said permeable hydrogen-selective membrane comprises a membrane material selected from the group consisting of perovskite-type ceramic materials, composites of Pd and ceramic materials, and combinations thereof.

19. An apparatus in accordance with Claim 18, wherein said permeable hydrogen-selective membrane comprises a ceramic material of perovskite oxide having a formula

$$A_{1-x}A'_xB_{1-y}B'_yO_{3-z}$$

where A is selected from the group consisting of Ba, Sr, Ca and Mg, A' is selected from the group consisting of La, Pr, Nd, Gd, and Yb, B and B' are selected from the group consisting of Ce, Nd, Sm, Eu, Gd, Tm, Yb and Y, O is oxygen, x and y are numbers in a range of 0 to 1, and z is a number sufficient to neutralize a charge in said perovskite oxide.

20. An apparatus in accordance with Claim 14, wherein said at least one permeable hydrogen-selective membrane is disposed within a membrane module disposed within said gas phase reactor vessel.

21. An apparatus in accordance with Claim 20, wherein said at least one permeable hydrogen-selective membrane is in one of a sheet form and a tubular form.

22. An apparatus in accordance with Claim 18, wherein said perovskite-type ceramic material comprises an electron conductive metal.

23. An apparatus in accordance with Claim 22, wherein said electron conductive metal is selected from the group consisting of Ni, Pd, Pt and combinations thereof.

24. A method for producing hydrogen comprising the steps of:

introducing a carbonaceous material into a reactor vessel suitable for gasifying said carbonaceous material;

converting said carbonaceous material to a product gas comprising hydrogen and at least one of CO, CO_2, CH_4, H_2O and H_2S; and

contacting a permeable hydrogen-selective membrane disposed within said reactor vessel with said product gas resulting in passage of at least a portion of said hydrogen through said permeable hydrogen-selective membrane, forming a hydrogen-rich gas and a non-permeate mixture.

25. A method in accordance with Claim 24, wherein said conversion is carried out in a fluidized bed disposed within said reactor vessel.

26. A method in accordance with Claim 24, wherein said permeable hydrogen-selective membrane is at least one of proton and electron conductive.

27. A method in accordance with Claim 24, wherein said permeable hydrogen-selective membrane comprises a membrane material selected from the group consisting of Pd, Pd-Ag alloy, Pd-Cu alloy, perovskite-type ceramic materials, composites of Pd and ceramic materials, and combinations thereof.

28. A method in accordance with Claim 24, wherein said reactor vessel is at a temperature in a range of about 700°C to about 2000°C.

29. A method in accordance with Claim 24, wherein said reactor vessel is at a pressure in a range of about 1 to about 200 atm.